Hydropower Investment Promotion Project (HIPP)

# LONG-TERM LOAD FORECASTING OPTIONS IN GEORGIA

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DELOITTE CONSULTING LLP
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**This document was prepared by:**


| Author | Organization | Contact Details |
| --- | --- | --- |
| Sophia Peter | Deloitte Consulting LLP | speters@deloitte.com |
| Gurgen Hakobyan | Deloitte Consulting LLP | gshakobyan@gmail.com |
| **Reviewer** | **Organization** | **Contact Details** |
| Jake Delphia | Deloitte Consulting LLP | jdelphia@deloitte.com |
| Dan Potash | Deloitte Consulting LLP | dpotash@deloitte.com |

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| Acronym | Term |
|---|---|
| **MoE** | Ministry of Energy of Georgia |
| **MIE** | Ministry of Industry and Energy of Azerbaijan |
| **MINENERGO** | Ministry of Energy of Russia |
| **GSE** | Georgian State Electrosystem |
| **TEIAS** | Turkish Electricity Transmission Company |
| **ESCO** | Electricity System Commercial Operator |
| **HPP** | Hydro Power Plant |
| **NPP** | Nuclear Power Plant |
| **TPP** | Thermal Power Plant |
| **PSRC** | Public Services Regulatory Commission of the Republic of Armenia |
| **GNERC** | Georgian National Energy and Water Supply Regulatory Commission |
| **IAEA** | International Atomic Energy Agency |
| **R2E2** | Renewable Resources and Energy Efficiency Fund |

## 1.0 INTRODUCTION

As part of the fundamental and wide-reaching changes to its energy sector, Georgia is moving toward a competitive electricity market. Under the USAID/Hydropower Investment Promotion Project, USAID has helped the Government of Georgia prepare its institutions for this process and to continue to attract private investment in its hydroelectric power market. Georgia is implementing a competitive power market model ("Georgian Electricity Market Model," or GEMM) and reforming its electric power sector for four main reasons:

- To secure domestic power supply for Georgia's population and industry
- To avail significant private investment for export-oriented hydropower plants located in Georgia
- To engage in beneficial electricity trade with Georgia's immediate neighbors: Turkey, Azerbaijan, and Armenia
- To harmonize and connect with the European Union for mutually beneficial electricity trade

An integral part of moving Georgia's energy institutions toward a competitive market is developing a process, context, and data to feed into a long-term load forecast for the country's electricity system.

Further described in the Background section below, a long-term load forecast uses a defined methodology to analyze the inputs into the country's electricity usage and, as an output, predicts future growth in the energy sector across technologies and different customer groups (i.e. residential, industrial, and commercial). Load forecasts are important for energy suppliers, ISOs, financial institutions, power utilities, and the other participants in the electricity generation, transmission, distribution and markets.

Until now, the vertically integrated Georgian power sector has operated without a long-term load forecast, and, as a consequence, has added generation and transmission capacity in a reactionary and unplanned manner. Putting in place a long-term load forecast will help Georgia with the following:

- **National Energy Policy**. Help setting national goals around energy growth, demand side management and other national electricity consumption issues.
- **Long-term Investment Plan for the Electricity Sector.** Help generate a clear signal to both investors and the government on where and how to build out generation, transmission, and distribution capacity;
- **Tariff Rate Structures**. Help the regulator have a better understanding of the energy coming online in order to regulate prices, profits, licensees etc.;
- **Capacity Adequacy Generation**. Help the electricity planning institutions understand how much generation needs to be brought on to ensure sustainable, reliable, affordable supply of energy to customers;
- **Forecasted Energy Balance**. Help the electricity planning agencies put in place policies that ensure an appropriate balance between energy supply and future demand;

As is clear above, the long-term load forecast is needed across the energy institutions in Georgia, including the Ministry of Energy, the TSO, GSE and ultimately GNERC, as well as private investors interested in investing in the country's infrastructure.

This report builds a case for developing a long-term load forecasting process in Georgia by discussing the background for load forecasting, describing potential load forecasting methodologies, acknowledging the challenges around forecasting new technologies and gathering input data, and, finally, discussing the forecast requirements for Georgia. It ends with a roadmap and recommendations on how to begin to build toward a rigorous, standardized long-term load forecasting structure for the country as its institutions continue to transition into a competitive market structure.

## 2.0 BACKGROUND

Electricity demand is not constant. It changes in a moment, during a day and over the years, in response to the seasons as well as consumer preferences. The power system must thus be designed to maintain a dynamic balance between the demand for electricity and the amount being supplied by generators and other supply sources. Both the transmission grid and distribution networks must be capable to transmit electricity from supply sources to demand centers and eventually end-users.

In growing economies with aging infrastructure like Georgia, the country's installed generation and network facilities are approaching their expected useful life, while the electricity demand is growing. Hence, the general expectation is that the existing capacities might be unable to meet current and expected demand.

Given the basic requirement for any power system to maintain its short- and long-term balance between supply and demand and to operate in compliance with applicable regulations and technical standards, it is clear that new capacities and/or refurbishment of existing facilities will be required. But how much new capacity is required? And which type of power generation? These questions should only be answered by a careful analysis of forecasted future electricity demand.

New generation, transmission, and/or large refurbishment projects cannot be implemented overnight. A series of specific actions is required to complete each one these projects in order to minimize cost, maximize public benefit, and ensure customers continue to have adequate, reliable, secure energy access. Most of these actions require time and effort[1] as well as the adoption of strategic and political decisions by government entities.

In case of deregulated electricity markets, the decision to bring online new generation and/or transmission or refurbish current assets are summarized within the National Energy Strategy and Policy, the Ten Year Network Development Plan (TYNDP), and reflected in amendments to existing legislation. With the adoption of GEMM, this is direction in which Georgia is moving.

In the meantime, a fragile balance needs to be maintained between attracting potential investors and protecting customer interests. While under a deregulated

1 Even assuming the availability of an investor, the construction of a new generating plant may take from as long as one year for gas-turbines to seven or more years for nuclear plants.

market potential investors assume most of the risks for investing in new generation, the attractiveness of legal, regulatory and business environment cannot be overestimated. Moreover, the transmission and distribution networks must plan their investments according to the expansion in generation.

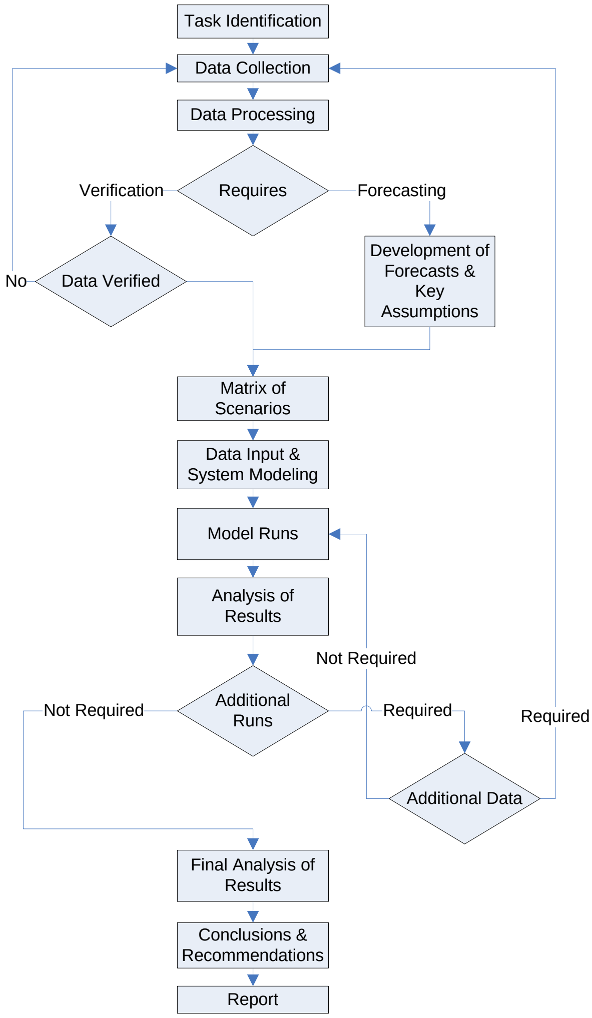
On the other side, any capital investment and/or other expected cost will be transferred to end-user prices. Minimizing extreme tariff spikes, ensuring the affordability of electricity for customers, and providing substantial development of the country's power sector are the central issues addressed in both the National Energy Strategy and Policy and TYNDP. This is central for to the country's energy security of the country as well as its programmatic approach to a sustainable, reliable, efficient and cost-effective power sector for its electricity consumers. Thus, the decisions about what is included in the National Energy Strategy and Policy and TYNDP shall be based upon a comprehensive and up-to-date evaluation and planning of the future of country's power sector.

If it does not begin to engage in a dynamic load forecasting process, Georgia will be building out its electricity system on unqualified assumptions—unnecessarily exposing itself to risks. Should it not build in enough capacity, the electricity system could again suffer from loadshedding, an inability to make good on its regional export contracts, and restricted access to electricity. Should it overbuild generation, the government will move forward with capital-intensive generation and transmission infrastructure that is not needed, inefficiently spending tight budgets, and artificially stimulating the economy.

Regular planning studies result in a country or a regional Least Cost Plans (LCP). A typical Least Cost Plan shall provide a supply plan for the future of the power sector and an action plan for the next two years for beginning its implementation. The study focuses on the expected costs of electricity generation and transmission by each specific type of power plant that could be realistically commissioned by the end of the planning horizon.

Figure 1 below shows a basic depiction of the typical least cost plan process.

**Figure 1: Typical Least Cost Plan (LCP) Process**




Although the required level of details varies among the tasks, long-term demand forecast has paramount importance for overall planning of the power system; development of the National Energy Strategy and Policy; design, development and investment planning of transmission and distribution grids; structuring tariffs and thus for sustainable operation of the power system.

## 3.0 DEMAND FORECASTING

There is an urgent need for precision in the demand forecasts. In view of the ongoing reform process, unbundling of electricity supply services, tariff reforms and rising role of the private sector, a realistic assessment of future electricity demand assumes an ever-greater importance. Demand forecasts are required not merely for ensuring optimal phasing of investments, a long term consideration, but also rationalizing pricing structures and designing demand side management programs.

Planning needs to be done well in advance. The construction period for new power plants typically varies between two to three years for a gas turbine to as long as four to twelve years in the case of large coal, hydro and nuclear plants. As a result, utilities must forecast demand for the long run (ten to 20 years), and make plans to construct facilities and begin development well before the plant is actually required.

As such, the demand forecast further drives various plans and decisions on investment, construction and conservation.

The nature of the forecasts has also changed over the years. It is no longer enough to predict the peak demand and the total energy use on an annual basis. Furthermore, the use of straightforward engineering approaches that focuses only physical factors can miss the emergence of new end-uses, as well as other effects such as the impact of rising energy prices as a stimulus to energy efficiency. The process of projecting the demand, now requires estimating market penetration of various devices, while accounting for fuel substitution, average future capacity and efficiency factors as well as average utilization rates, etc. In the process of making predictions, a forecaster needs to bear in mind the feedback effects of pricing and other policy changes. As economies grow, generate new industry, use new devices and expand their populations, the forecast becomes increasingly more complicated.

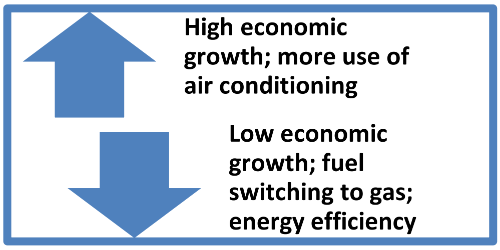



**Figure 2: Load Forecast Can Vary by Different Impact Factors**

A precise estimate of demand is important for the purpose of setting tariffs. A detailed customer class consumption forecast helps in the determination of a just and reasonable tariff structure wherein no consumer pays less than the cost incurred by the utility for supplying the power. Furthermore, the utility can also plan the power purchase requirements to meet the demand while maintaining the merit order dispatch to achieve optimization in the use of their resources.

To deal with all of these complicated factors, many forecasting techniques have been developed, ranging from very simple extrapolation methods to more complex time series techniques, extensive accounting frameworks and optimization methods, and even hybrid models that use a combination of these for purposes of prediction.

The following section discusses these different forecasting methods as well as their pros and cons.

## 4.0 FORECASTING METHODS

Electricity is a single homogeneous commodity. However, a diverse customer base creates a wide range of dissimilar demands. The need and relevance of forecasting demand for an electric sector has become an oft-discussed issue in the recent past. This has led to the development of various new forecasting tools and methods.

In the past, straight-line extrapolations of historical energy consumption trends served met the demands of the electricity system. However, with the onset of inflation and rapidly rising energy prices, emergence of alternative fuels and technologies (in energy supply and end-use), changes in lifestyles, institutional changes etc., it has become imperative to use modeling techniques which capture the effect of factors such as prices, income, population, technology and other economic, demographic, policy and technological variables.

There is an array of methods that are available today for forecasting demand. Some of these methods are simplistic; others are more sophisticated and require detailed and very accurate input data and information (classified end-use, various impact factors such as energy prices and their effects, real GDP, etc.). Accurate statistical data are fundamental for identifying the changes in consumption patterns for each customer class, or the impacts of energy efficiency and demand-side management programs on the overall system load, establishing trends in customer class consumptions, demand forecasts, and tariff setting.

An appropriate method is chosen based on the nature of the data available and the desired nature and level of detail of the forecasts. Due to a lack of accurate and reliable input data, sometimes forecasters must employ more general approaches and consider various cases or scenarios in order to evaluate the sensitivity of results.

An approach often used is to employ more than one method and then to compare the forecasts to arrive at a more accurate forecast. The forecaster may use a combination of techniques that give him aggregate annual forecasts and those that predict hour-by hour demand for electricity in individual sectors.

It is worth noting that the collection and validation of available data, selection of a forecasting method based on data availability and accuracy, and further verification of the forecast results is an iterative process. Usually previous forecasts require a periodic revision and verification based on newly available data.

The section below describes basic principles of most commonly used forecasting methods and approaches.

## 4.1 Trend Method

This method falls under the category of the non-causal models of demand forecasting that do not explain how the values of the variable being projected are determined. Here, we express the variable to be predicted purely as a function of time, rather than by relating it to other economic, demographic, policy and technological variables. This function of time is obtained as the function that best explains the available data, and is observed to be most suitable for short-term projections.

The trend method has the advantage of its simplicity and ease of use. However, the main disadvantage of this approach lies in the fact that it ignores possible interaction of the variable under study with other economic factors.

For example, the role of incomes, prices, population growth and urbanization, policy changes etc., are all ignored by the method. The underlying notion of trend analysis is that time is the factor determining the value of the variable under study, or in other words, the pattern of the variable in the past will continue into the future. Therefore, it does not offer any scope to internalize the changes in factors such as the effects of government policy, underlying institutional structure, regulatory regimes, demographic trends, aggregate and per capita growth in incomes, technological developments etc.

However, this method is important as it provides a preliminary estimate of the forecasted value of the variable. It may well serve as a useful cross check in the case of short-term forecasts.

### 4.2 End Use Method

The end-use approach attempts to capture the impact of energy usage patterns of various devices and systems. The end-use models for electricity demand focus on its various uses in the residential, commercial, agriculture and industrial sectors of the economy. For example, in the residential sector electricity is used for cooking, space heating, air conditioning, refrigeration, and lighting. The end-use method is based on the premise that energy is required for the service that it delivers and not as a final good.

The following relation defines the end use methodology for a sector:

$$\mathbf{E = S \times N \times P \times H}$$

*Where:*
*E = energy consumption of an appliance in kWh;*
*S = penetration level in terms of number of such appliances per customer;*
*N = number of customers;*
*P = power required by the appliance in kW;*
*H = hours of appliance use.*

This, when summed over different end-uses in a sector, gives the aggregate energy demand. This method takes into account improvements in efficiency of energy use, utilization rates, inter-fuel substitution etc., in a sector as these are captured in the power required by an appliance, P. In the process the approach implicitly captures the price, income and other economic and policy effects as well.

The end-use approach is most effective when new technologies and fuels have to be introduced and when there is lack of adequate time-series data on trends in consumption and other variables. However, the approach demands a high level of detail on each of the end-uses. One criticism raised against the method is that it may lead to a mechanical forecasting of demands, without adequate regard for behavioral responses of consumers. Also, it also does not give regard to the variations in the consumption patterns due to demographic, socio-economic, or cultural factors. A feature of this method is that the data is collected with a picture of the end result in mind. Therefore, the degree of detail required in the data depends on the desired nature of the forecasts.

### 4.3 Econometric Approach

This approach combines economic theory with statistical methods to produce a system of equations for forecasting energy demand. Taking time-series[2] or cross-sectional/pooled data[3], causal relationships[4] could be established between electricity demand and other economic variables. The dependent variable, in our case, demand for electricity, is expressed as a function of various economic factors. These variables could be population, income per capita or value added or output (in industry or commercial sectors), price of power, price(s) of alternative fuels (that could be used as substitutes), proxies for penetration of appliances/equipment (capture technology effect in case of industries) etc. Thus, it can be expressed as:

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2 Detailed data over the last, some 25 to 30 years.

3 Detailed data pooled over different regions/states/individuals and time as well.

4 Functional forms where a cause-and-effect relationship is established between variables.

**ED = f (Y, Pi, Pj, POP, T)**

*Where:*
*ED = electricity demand*
*Y = output or income*
*$P_i$ = own price*
*$P_j$ = price of related fuels*
*POP = population*
*T = technology*

Several functional forms and combinations of these and other variables may have to be tried until the basic assumptions of the model are met and the relationship is found statistically significant. For example, the demand for energy in specific sectors could be explained as a function of the variables indicated in the right hand side of the following equations:

**Residential ED = f (Y per capita, POP, $P_i$, $P_j$)**

**Industrial ED = g (Y of power intensive industries, GFCF or I, T, GP)**

*Where:*
*GFCF = gross fixed capital formation;*
*I = investment;*
*GP = government policy, and,*
*f and g represent functional forms.*

Inserting forecasts of the independent variables into the equation would yield the projections of electricity demand. The sign and the coefficients of each variable, thus estimated, would indicate the direction and strength of each of the right-hand-side variable in explaining the demand in a sector.

The econometric methods require a consistent set of information over a reasonably long duration. This requirement forms a pre-requisite for establishing both short-term and long-term relationships between the variables involved. Thus, for instance, if one were interested in knowing the price elasticity of demand, it is hard to arrive at any meaningful estimates, given the long period of administered tariffs and supply bottlenecks. However, the price effect will have an important role to play in the years to come. In such a case, one may have to broaden the set of explanatory variables apart from relying on more rigorous econometric techniques to get around the problem. Another criticism of this method is that during the process of forecasting it is incorrect to assume a particular growth rate for the explanatory variables. Further, the approach fails to incorporate or capture, in any way, the role of certain policy measures/economic shocks that might otherwise result in a change in the behavior of the variable being explained. This would have to be built into the model, maybe in the form of structural changes.

### 4.4 Fuel Share Model

A variant of econometric models, the category of fuel share models consider a two-step approach for estimating energy demands. First, the total energy consumption by a sector is estimated, which is then used in the determination of fuel shares, defined as ratios of individual fuels consumed to the total energy consumption by the sector.

Emphasizing the dependence of fuel shares on relative fuel prices brings the focus on inter-fuel substitution.

A drawback of this method is its failure to recognize the interdependence between prices and quantity. The estimating equations assume that fuel prices are determined independently of both total energy consumption and the distribution of consumption by fuels. The sequential estimation procedure also assumes that total energy consumption is independent of fuel shares. Thus, all fuel supplies must be perfectly elastic and price elasticity are meaningful only if total energy demand remains fixed in response to a change in relative prices.

Also the aggregate energy quantities and prices are weighted averages of individual fuels expressed in common heat units, which is acceptable only if all fuels are substitutable in different applications. The weights are unaffected by relative prices making the aggregation procedure inconsistent with the premise that fuel shares shift in response to relative fuel prices.

All the models built using this approach have predicted that electricity demand is highly price-responsive. Also, energy prices are important in determining both total energy consumption and the fuel choice while income is more important in determining total energy demand than the fuel choice. Thus the expectations based on demand theory that relative fuel prices, not income, affect fuel choices, while both determine the energy consumption levels. The strength of these relationships, however, is still to be established beyond doubt.

### 4.5 Time Series Methods

A time series is defined to be an ordered set of data values of a certain variable. Time series models are, essentially, econometric models where the only explanatory variables used are lagged values of the variable to be explained and predicted. The intuition underlying time-series processes is that the future behavior of variables is related to its past values, both actual and predicted, with some adaptation/adjustment built-in to take care of how past realizations deviated from those expected. Thus, the essential prerequisite for a time series forecasting technique is data for the last 20 to30 time periods.

The difference between econometric models based on time series data and time series models lies in the explanatory variables used. It is worthwhile to highlight here that in an econometric model, the explanatory variables (such as incomes, prices, population etc.) are used as causal factors while in the case of time series models only lagged (or previous) values of the same variable are used in the prediction.

In general, the most valuable applications of time series come from developing short-term forecasts, for example monthly models of demand for three years or less. Econometric models are usually preferred for long term forecasts.

Another advantage of time series models is their structural simplicity. They do not require collection of data on multiple variables. Observations on the variable under study are completely sufficient. A disadvantage of these models, however, is that they do not describe a cause-and-effect relationship. Thus, a time series does not provide insights into why changes occurred in the variable.

Often in analysis of time series data, either by using econometric methods or time series models, there do exist technical problems wherein more than one of the variables is highly correlated with another (multi-collinearity), or with its own past values (auto-correlation). This sort of a behavior between variables that are being used to arrive at any forecasts demands careful treatment prior to any further analysis. These, along with other similar methodological options, need a careful assessment while working out forecasts of demand for any sector.

### 4.6 Co-Integration

Essentially a variant of the time-series approach, this method attempts to overcome some of the limitations of the simple econometric forecasts wherein we prescribe a growth rate to the explanatory economic factors.

The underlying concept here is that the overall pattern or relationship between any set of variables is likely to persist into the future as well. It is observed that some economic variables tend to behave in a similar fashion in the long run. That is to say that there is an implicit time-trend in the pattern of variables. In such a case, it is often found that these factors have significant causal effects on each other.

An example often cited is that of per capita GDP and per capita consumption. It is seen that with an increase in the per capita GDP, there is an increase in the per capita consumption. This in turn leads to an increase in the per capita GDP. Thus, in the long run, per capita GDP and per capita consumption tend to follow the same pattern. In such a case we say that the two series are co-integrated. The long run (common) equation capturing the relationship between the variables involved is called the co-integrating vector. Various software packages have now been developed that can establish such relationships with a fair degree of simplicity and then utilize them for arriving at future projections.

If any two series are co-integrated, the process of building the model differs slightly from that in the case of a simple econometric model. We use a system of equations to build the model as against just one equation, as in the case of a simple econometric or time series model. In addition we also include an additional term called, the “error correction term” to account for the long run effects, while the short run effects are captured by the co-integrating vector.

The advantage of this technique is that one does not need to prescribe the growth rates of any of the variables that are co-integrated with one another.

The system of equations internally generates the forecasted values of the variables involved, based on the long-run pattern established in the past. In addition, introducing shocks into the system could capture the effect of policy implications. The major disadvantage of this approach is the need for a consistent time-series spanning at least 30 time-periods as a pre-requisite.

### 4.7 Hybrid Methods: Integration of Econometric & Time Series Models

It is common to use a combination of econometric and time series models to achieve greater precision in the forecasts. This has the advantage of establishing causal relationships as in an econometric model along with the dependency relationship. Various functional forms such as linear, quadratic, log-linear, translog, etc are used to capture the possible trends that may be evident in the data. The functional form of the model is arrived at after a trial and error process.

A model is built using the available data, truncating the last few observations. The procedure for testing the model entails making predictions for the last few time periods for which actual data are available and were truncated.

The functional form where the forecasts have least deviations from the data available is chosen.

### 4.8 Hybrid Methods: Integration of Econometric and End-Use Approach

A bulk of empirical literature suggests a hybrid of end-use and econometric method for forecasting. This would allow integration of physical and behavioral factors in a common framework: while the econometric relationships would internalize the influence of price, income and policy effects, the end-use approach will provide an accounting plane for aggregating end-use and sectoral energy demands projected into the future. The accounting framework accommodates new end-uses, alternative fuel mixes, penetration of appliances and technologies, growth pattern of physical or value of output, population and its distribution amongst income class. The integrated approach will provide a better grasp of many diverse influences that shape the demand for energy into the future.

### 4.9 Predicting the Shape of the Load Curve

This can be classified into three techniques: disaggregation, aggregation and econometric methods. Each type can use various principles of engineering estimation and econometrics in their execution.

Disaggregation basically refers to starting with a known shape, decomposing it into components to the extent necessary, making modifications for demand side management and recombining to provide an estimate of the load shape after measures towards demand side management have been undertaken.

The initial load shape is estimated using econometric or regression methods. This technique is quite useful in making early estimates of load shape impacts. The level of detail in the decomposition, possible concerns regarding accuracy and its response to weather are, however, shortfalls of this method.

Aggregation, as opposed to disaggregation, is based on the principle of building up or aggregating the load shape to enable structuring a load shape and to explicitly include consideration of demand side management programs or initiatives as a part of the process.

## 5.0 FORECASTING NEW TECHNOLOGIES

An integral part of the forecasting process is taking into account the effect of new technologies and their estimated usage on the future consumption, efficiency and losses of electricity.

These new products, along with the direct effect of the new technology, have a significant impact on the demand for electricity. Since there is no historical data available, classical techniques are not applicable here and a high degree of complex technical input into the decision process is required. Based on the data available, the forecaster has to choose between a subjective and an objective model.

Subjective models do not specify processes and the data is analyzed informally using judgment and experience as against objective methods where the process to analyze the data is clearly specified.

The Electric Power Research Institute (EPRI), an internationally respected institute on electricity sector issues, has logically divided forecasting methods into three branching pairs: judgmental and model-based; extrapolation and causal; and static and dynamic.

Judgmental forecasting methods are mental processes that people use to make predictions. They can be simple or complex and may use quantitative or qualitative data as inputs. This method relies on the experience and perceptions of the forecaster and is easily implemented at a low cost. They are useful when little or no historical data is available, when the past does not significantly affect the future, or when explanation and sensitivity analysis are not required.

A popular judgmental approach is that of historical analogies. This approach assumes that similar technologies exist that have preceded a new technology and that the analyst can use the historical penetration of the previous product to gauge the success of the present product. The underlying assumption, in the absence of which this method is not justifiable, is that the earlier product or technology had a similar economic/market environment during its introductory stage as does the current product.

Model-based methods use well-specified algorithms to process and analyze data. These algorithms are repeatable and can be based on quantitative or qualitative input data. Usually the extrapolation and causal methods are included in this category.

Extrapolation methods are numerical algorithms that help forecasters find patterns in time-series observations of a quantitative variable. These are popular for short-range forecasting. This method is based on the assumption of continuity and projects historical patterns into the future. Thus, it requires data only on the variable being forecasted for a sufficient historical time-series.

Causal methods rely on the assumption that a stable, systematic structure accounts for changes that the forecast variable will undergo in the future. These models can be simple, such as the single-independent-variable linear equation specification, or complex using nonlinear, simultaneous equations, each with several independent variables.

These methods may be static or dynamic or a blend of the two. A static forecast is used to forecast into the near future and uses actual data for the variables in the past or the present. On the other hand, a dynamic forecast can be used to make long term projections since it uses the forecasted values to predict later in the future.

Econometric techniques involve prescribing a relationship between hourly load and major variables such as energy prices, income levels, and appliance saturation rates. These relationships are organized into the form of equations, parameters are estimated based on historic data, and then the equations are used to forecast.

### 5.1 New Technologies in Georgia

This situation is particularly poignant in Georgia, where new residential appliances are taking hold, the middle class continues to expand, commercial sector patterns shift, and residential consumer preferences change given as a result of increased average per capita income. Of particular relevance in Georgia is the increased penetration of air conditioning, which historically has led to higher peak demand in the summer as well as the switch to natural gas for heating in the winter away from electric heating. In general, this has led to an increase in the amount in energy consumed in the residential sector and a general flattening of the annual load curve. In the commercial sector, the country is moving into new sectors of economic growth, including information technology, tourism, and new agricultural products, which will all employ new technologies, appliances, and products, and, as a result, impact the load curve for that customer class. The role of these new technologies in the various customer classes emphasizes the importance of input data and highlights the necessity of surveying these different customer classes to arrive at data-driven results.

## 6.0 THE IMPORTANCE OF INPUT DATA

Forecasting as well as power generation and transmission planning requires a wide spectrum of accurate data on different aspects of the electric power system. The quality of the planning results is very dependent on the quality of input data. In this respect, planning studies face a great challenge because both the availability and reliability of the data are usually far from satisfactory. In most cases, the data obtained needs additional processing, validation, and comparison with data from other sources.

The data and results of previous studies and reports constitute a large part of the initial data set. However, in many cases this data is outdated and contains inconsistencies and contradictions. Because of this, considerable time is being spent on the validation and verification of the available data. Then the data and the results of most recent studies and reports shall be reviewed based on the actual data collected during the last few years.

Given the fast changing power scenario in the country, a move to better forecasting methods cannot be underestimated. Indeed, while one would face problems with availability of information, initiating work with better methods would provide the impetus for collection and collation of the information that would form the backbone of any useful exercise.

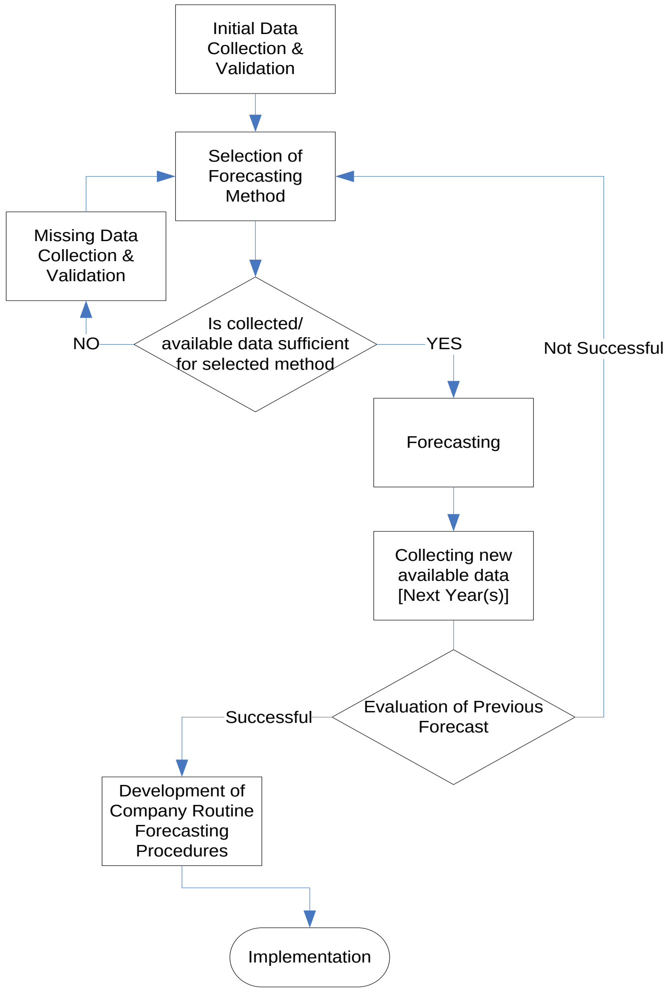
Specifically, the effective use of end-use methods would require that extensive primary-level surveys be carried out to build and consolidate a reliable database on end-uses of energy in the different customer classes.

It is also noteworthy that the time series data available in Georgia is admittedly unreliable. A greater transparency in documentation of sectoral consumption is clearly impending, especially to provide a boost to private sector initiative in generation and sales of electricity.

It is worth mentioning that all the forecasting methods available today are highly data intensive. The accuracy of the forecast increases with the quality and quantity of input data used to arrive at the model. However, there is a practical limit to the quantity of data that is cost effective to gather and manipulate in terms of additional information gained by the utility planner. Studies are on, the world over, to develop new techniques that would reduce the amount of data required for a given level of accuracy to be achieved in the forecast.

Unless the GOG begins to make inroads now on data collection and forecasting quality, it will not be possible to keep up with the demands placed by a fast changing economic scenario for power in the European Union and around the world.

### Figure 3: Selection of Forecasting Method and a Typical Forecasting Flowchart



## 7.0 FORECAST REQUIREMENTS FOR GEORGIA

As mentioned above, various tasks and thus selected forecasting methods require different level of details. Both the amount and character of input and output data varies depending on the expected outcome (e.g. distribution network investment planning requires a demand forecast by transformer and feeder level, while long term system generation adequacy would only need system combined projections).

Most of the energy sector entities in Georgia will use the results of a long-term load forecast for the country in their GEMM2015 and other outputs. The table below summarizes major tasks ahead, necessary inputs, the stakeholders, most commonly used software tools, and expected outcomes.

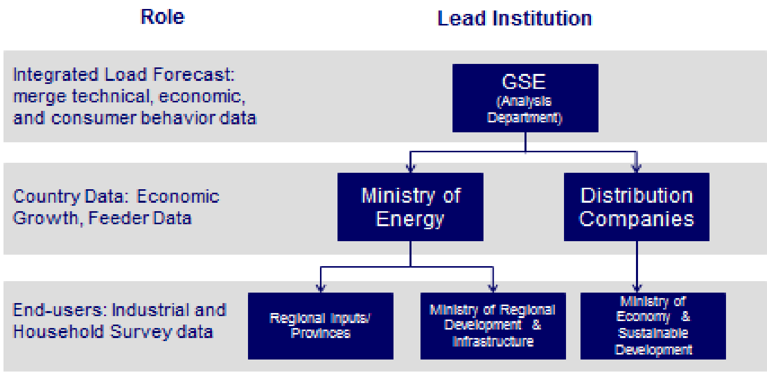
### Figure 4: Load Forecast Models for Georgia

| Task/Outcome | Stakeholders | Software / Tool for this Purpose | Input Data from Load Forecast |
|---|---|---|---|
| **National Energy Policy & Strategy** | • MoE<br>• MoEc<br>• MoENRP<br>• GNERC<br>• TSO | • MARKAL<br>• Other | • Historical load data<br>• Weather data/temperature<br>• Number of customers in different categories: residential, commercial, industrial<br>• Various appliances in the area<br>• Economic and demographic data and its forecast<br>• End-use load shape: A/C, lighting, heating, appliances, transport (substitution) |
| **Transmission & Distribution Investment Planning** | • TSO<br>• Transmission Licensees<br>• Distribution Licensees | • PSS/E<br>• Power Factory<br>• GTMAX<br>• OPF<br>• Other | • Daily demand by node or even by feeder |
| **Tariffs for Transmission & Distribution** | • Regulator<br>• TSO<br>• Transmission<br>• Distribution | • MS Excel | • National power and energy demand, seasonal or monthly |
| **Generation Capacity Adequacy Planning** | • TSO<br>• MoE<br>• GNERC | • WASP-IV<br>• IPM<br>• AURORA<br>• Other | • National power and energy demand, seasonal or monthly, by node or area |
| **Forecasted Energy Balance (Electricity)** | • MoE<br>• TSO | • MS Excel | • National power and energy demand, seasonal or monthly |

## 8.0 A LOAD FORECAST ROADMAP FOR GEORGIA

This report has built the case for mainstreaming a long-term load forecast into the Georgian electricity sector's planning process. In order to move toward that eventual vision, this report suggests the following roadmap to put the necessary pieces in place for a standardized, regular long-term load forecast process.

**Figure 5: Suggested Assignment of Responsibilities for Electricity Load Forecasting in Georgia**




1.) **Select a Load Forecast Methodology**

Once the energy sector entity in charge of annual load forecast has been selected, the agency should work with stakeholders to select the initial load forecast methodology that Georgia will use for its long-term load forecasting. Figure 5 uses GSE as that central load forecasting institution. Then, internal capacity needs to be built within the lead institution around the load forecasting model, so that this institution can both run the model as well as coordination the distribution and discussion of the outputs with other interested stakeholders (i.e. other GOG entities, investors, ENTO-E entities, etc.). This will involve trainings on the software, standardizing and mapping the new processes, and understanding all of the impacted stakeholders and their role in the load forecast process.

2.) **Standardized the Process and Collect the Data Inputs**

The different load forecast models require different data inputs. Therefore, once the methodology has been agreed upon, the necessary data inputs will be evident, guided by the table in Figure 4 above. The lead institution needs to spur the requisite agencies to collect that information and report it back in a way that is analyzable. In most cases, this will require new surveys, proxy data, and/or limited data collection methods. The way in which this data is collected needs to be agreed-upon, but should standardized and well-documented, in line with international standards when appropriate. In deciding how to collect that data, the thoroughness of the input data needs to be balanced with investment needed to collect this data.

3.) **Mainstream the Load Forecast Results into GoG Outputs**

Once the load forecast methodology has been decided and input data collected, the load forecast should be shared across agencies, investors, and other relevant regional stakeholders. To the extent possible, these agencies should begin to build their outputs around the results from the load forecast. It should be posted in a public place and easily accessible. The country's energy sector policies and electricity sector expansion plans need to be synced, in order to ensure cost-saving and coordination across the government's growth plan. As a result, it is of the utmost importance that the load forecast each of the agencies uses for their planning comes from a central, standardized source.

## 9.0 CONCLUSIONS & RECOMMENDATIONS

In view of the fast changing power scenario and electricity sector in Georgia, the need for more sophisticated and relevant forecasting tools and methods for estimating demands has emerged in a way the country has not seen before. Clearly, it is time that energy planning entities adopt a proactive approach to initiate engage better methods, which would also provide the much needed impetus for standardized data collection. This could, in turn, feed effectively into the electricity reform processes. With this now underway, the time is now to engage these new forecasting methods: To do so, the following next steps are recommended:

- **Move toward more sophisticated power forecasting models.** In respect of the annual forecasts, as a result of excessive reliance on simple extrapolation of past rates of growth or trend, power forecasting in Georgia is not at the level it needs to be, both in terms of rigor and precision. Given the prevailing conditions in the Georgian power sector, it is advisable to begin using simple time-series or econometric methods and/or utilize more extensive end-use approaches for purpose of forecasting, should input data be available. With independent regulation, pricing and related policy reforms will have an ever increasing impact on demands. Thus, given the data constraints, it might be preferable to depend on a hybrid technique discussed above to suit individual requirements.
- **Begin to determine basic seasonal and daily load shapes for Georgia**. With renewed focus on demand side management and role of new technologies, the need for determining the shape of the load curve and predicting the impact of new technologies has gained additional importance. Thus, new methods will have to be deployed to estimate the demand variations across hours, weeks, months and even regions.
- **Standardize data inputs and collection methods at the inception.** Looking forward, we recommend that, after requisite consultations with all stakeholders, homogeneous standards be laid down for data collection and reporting. The GoG should strive toward a standardized repository of data/information for each state; therefore, as the grid gets more connected, there would be comparable databases across the country allowing analyses for groups of states or a regions of the country as a whole to be seamlessly weaved together in the load forecast.
- **Train stakeholders on the importance of a load forecast and quality input data.** As the different government agencies in the electricity sector begin to transition toward competitive market entities, it is important to discuss the importance of demand forecasts and standardized data inputs with the staff of these agencies in order to help them both begin to generate basic demand forecast models, and eventually mainstream the outputs of these models into their decision-making process. It is of the utmost important that all of the GoG entities use the same the forecasting methodology and inputs, as coordinated future activities must be built on the same initial assumptions, which will be dictated by an agreed upon model and standardized data inputs.

- **Coordinate the stakeholders that will use the load forecast and TYNDP.** In an effort to develop a commonly agreed-upon database, which would enable the effective use of the techniques discussed above, collaboration and cooperation among the various government departments and agencies such as the MoE, GNERC, Geostat, etc. would be an advantage. Increased interaction between these departments on data collection and standardized demand forecast inputs is therefore suggested to achieve increased efficiency in demand forecasting.

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USAID Hydropower Investment Promotion Project (USAID-HIPP)

Deloitte Consulting Overseas Projects - HIPP

Tiflis Business Centre, 13th Floor

11 Apakidze Street

Tbilisi, 0171, Georgia